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POPULATIONS OF THE BERYCOID FISH FAMILY POLYMIXIIDAE

By Ernest A. Lachner

The contributions in this study are the presentation of data mainly from heretofore unreported collections warranting the recognition of three species of *Polymixia*, new evidence establishing two species in Atlantic waters, and great extensions of the geographic distributions of all forms.

This family, with a single genus, has had seven nominal forms referred to it. Nineteenth century interest in exploration and natural history accounted for the almost simultaneous descriptions of two species from each of two different geographical areas, *Polymixia nobilis* Lowe (1836) from Madeira and *Nemobrama webbii* Valenciennes (1843) from a contiguous area, the Canary Islands, and *P. lowei* Günther (1859) and *Dinemus venustus* Poey (1860) from Cuba. There is disagreement in the literature on the exact dates of publication of the descriptions of *P. nobilis* and *N. webbii*. Some authors have given 1838 for the former. Valencienne's "Icththyologie," in Baker-Webb and Berthelot, "Histoire Naturelle des Îles Canaries," volume 2, part 2, has been listed under several dates and more generally by some as 1836–44. There is no question of priority, for Valenciennes mentions *nobilis* in his study. I follow Neave (1940) for my dates of these references.

The osteology, anatomy, and classification of the berycoid fishes have been generally treated by Starks (1904) and Regan (1911). The Polymixiidae, possessing a unique pair of chin barbels, were incorrectly related to the Mullidae by many earlier workers owing to this superficial character. Several distinct fossil genera are known dating as early as the Cretaceous, but only one living genus exists. David (1946, p. 63) described a new fossil genus, *Parapolymixia*, based on scales from the California Eogene, but the differences when compared to *Polymixia* are not explicit and may represent only a specific level of differentiation.

Collections and methods

A total of 277 specimens were available for study from the eastern and western Atlantic Ocean and the western Pacific Ocean. I have also seen or have had examined for me the types of six of the seven nominal forms. All collections and types are listed by geographic areas in the descriptions of the respective species.

I am greatly indebted to several of my colleagues who generously made available to me collections and certain information. Special thanks are due William C. Schroeder, Museum of Comparative Zoology (MCZ), for making available the extensive collections from Cuban waters taken by him on the *Atlantis* expedition under the joint auspices of Harvard University and the University of Havana, and also specimens taken in deep waters off Long Island, N. Y., by the Woods Hole Oceanographic expeditions (*Captain Bill II*), as well as other miscellaneous specimens and types of *Dinemus venustus* Poey in the Museum of Comparative Zoology. My appreciation is also extended to: Dr. Reeve M. Bailey, Museum of Zoology, University of Michigan (UMMZ), for the loan of specimens from Japan; Loren P. Woods, Chicago Natural History Museum (CNHM), for data from specimens from Madeira, the Gulf of Mexico, and Japan; John T. Nichols, American Museum of Natural History, New York (AMNH), who made available the types of *P. nobilis virginica* Nichols and Firth and a specimen from Japan; Alwyne C. Wheeler, British Museum (Natural History) (BM), for providing me with data from the types of *P. nobilis* Lowe, *P. lowei* Günther, and *P. japonica* Günther, data from several specimens from Madeira, St. Helena, and Japan, and an X-ray photograph of the type of *japonica*. All other collections listed, including the type of *P. berndti* Gilbert, are in the U. S. National Museum (USNM). Isaac Ginsburg, U. S. Fish and Wildlife Service, made available 50 specimens of *lowei* (USNM 157749–54) from the Gulf of Mexico taken by the U. S. Fish and Wildlife Service Exploratory Fishing Vessel *Oregon*. Dr. Fenner

Chace, division of marine invertebrates, U. S. National Museum, presented me with considerable literature on the distribution of marine invertebrates in the Atlantic Ocean.

The method of recording counts and measurements of several characters require explanation because they present certain specific or unique problems in this group. The last ray of the SOFT DORSAL FIN is nearly divided to its base and may be erroneously interpreted as two. One must be especially cautious when the fins are badly frayed and torn. All rays of the PECTORAL FIN were counted. The VERTICAL SCALE ROWS were counted by noting the oblique rows on the body above the lateral line, commencing with the row at the junction of the lateral line and the gill opening, and counting posteriorly to the end of the hypural plate. This count was less variable than counting the scales along the lateral line and can be made with greater accuracy. The LATERAL LINE PORES were counted from the upper edge of the gill opening to the end of the hypural plate. The TOTAL NUMBER OF GILL RAKERS recorded includes all developed rakers on the upper and lower limbs of the first right arch. Several depressed, usually elongate rudiments occur adjacent to the last, small, pointed raker on the lower arch. These were omitted from the count for two or more may be coalesced. A small tubercle may also occur adjacent to the last, small, raker on the lower arch. When this tubercle was higher than the diameter of its base it was considered as a raker and included in the count, and when smaller it was considered as a rudiment. There is a reduction in the number of gill rakers with increase in body size, giving rise to the negatively skewed curve as shown by the frequency distribution of the total number of gill rakers of *lowei* from Cuba in table 2. This is due to the presence of a larger number of small specimens. The positively skewed curve shown for the same species from the Gulf of Mexico was caused by the great number of large specimens. The longest measurement of the UPPER JAW was taken because the jaw has a cleft at the symphysis. The LENGTH OF THE PECTORAL FIN was measured from the tip of the longest ray to the anteriormost portion of its base. All measurements of the LENGTH OF A FISH refer to the standard length. In the numerical data given in the description, the mean is listed first, and it is followed by the range of variation for each character showing interspecific differences.

Diagnostic characters

The species have differentiated almost entirely in meristic characters. The data are tabulated in the form of frequency distributions in tables 1 to 6, and in most cases are segregated by localities.

The number of dorsal fin rays and the total number of gill rakers proved to be the most critical characters in the separation of the species. The interesting negative correlation between these two characters accounts for the greater departure between the frequency distributions of *nobilis* and *lowei* when a character index is formed by subtracting for each individual specimen the total number of gill rakers from the number of soft dorsal fin rays (table 3). Each of these characters or their combination expressed as an index did not completely separate all specimens of the three species, small overlaps occurring among the distributions. The exact nature of these overlaps and other reasons for the recognition of the species are discussed under the description of each species.

The number of anal fin rays may prove to be of value in separating eastern and western populations of *nobilis* (table 5). Four specimens from Madeira had an anal fin ray count of 17 to 18, and five from Cuba had only 16 rays. No doubt larger collections will reveal some overlap, but this is sufficient indication that some differentiation has occurred between these populations. This character is certainly not very variable, judged from the nature of the modality of specimens of *lowei* from Cuba and the Gulf of Mexico. I hesitate to name this Cuban population because of lack of sufficient material and because all three species are not completely separable in themselves. The divergence of the characters in the various populations is quite irregular and difficult to evaluate in respect to the real biological differentiation. The single specimen from the Hawaiian Islands has a higher anal ray count than the 25 specimens from Japan and the Philippine Islands. Here again is a suggestion of population divergence, but any reliable allocation of rank must await additional collections.

Evidence of differentiation between the Japanese and Philippine populations of *japonica* is shown in the tabular data on the number of pectoral fin rays, lateral line pores, and vertical scale rows and the length of the chin barbel, but these require substantial verification.

Geographic distribution

The family has a global distribution in tropical and semitropical waters where they are generally taken near some continental land mass at depths of 150 to 350 fathoms, although some have been captured in less than 50 fathoms. The species are considerably more widely distributed than previously reported. The eastern Atlantic form, *nobilis,* is reported for the first time from the western Atlantic. The distribution of the western Atlantic form, *lowei,* is now more widely known from the Gulf of Mexico and as far north along the Atlantic shelf as New York. The Pacific species, *japonica,* is now reported from the Philippine Islands (not included in Herre's 1953 checklist), but not yet known from Indo-Australian waters (Weber and de Beaufort, 1929, p. 215).

In the future, in concentrated collecting such as was done in Cuban waters by the *Atlantis* expedition, all the species may be found to be more widely distributed than now known, as well as being locally abundant. The capture in one net haul in Cuban waters of more than 300 specimens of *lowei,* heretofore reported as rare, actually shows how inadequately the seas have been sampled (see discussion, *P. lowei*).

The geographic distribution of *nobilis* is of interest in view of its possible differentiation in the eastern and western Atlantic faunas.

The various literature on inshore fishes indicate that differentiation of populations between these two general faunal areas may be expected at all degrees to the specific level; some apparently show no differentiation. Actually, no detailed taxonomic study has been completed of any natural group of fishes wherein the species are supposed to inhabit both faunal areas. Some authors have published accounts and lists (Norman, 1935, p. 56) of species common to both faunas, but these should be regarded with considerable skepticism in the absence of critical data. A number of marine invertebrates are apparently common to both faunas. For those interested in comparative geographical distributional patterns the following will be of interest. Holthuis: 1952, page 15, *Pontonia domestica,* Madeira, Bahamas, and Atlantic coast of the United States from South Carolina to Louisiana; and 1947, page 77, *Rhynchocinetes rigens,* Madeira, Bermuda. Schmitt: 1935, page 128, *Penaeus brasiliensis,* from about Long Island Sound to Brazil, West Africa, Puerto Rico, St. Thomas; and page 217, *Hippa cubensis,* Florida to Brazil, West Indies, West Africa, Ascension Island, Puerto Rico, St. Thomas. Rathbun: 1933, page 49, *Callinectes marginatus*; page 68, *Chlorodiella longimana;* page 69, *Menippe nodifrons;* page 86, *Grapsus grapsus;* page 87, *Goniopsis cruentata;* and page 89, *Pachygrapsus gracilis;* all more or less with the same type of distribution as those above. No outstanding population differentiation in these invertebrate forms was noted.

Genus *Polymixia* Lowe

Polymixia Lowe, 1836, p. 198 (type species, *Polymixia nobilis* Lowe).
Nemobrama Valenciennes, 1843, p. 40 (type species, *Nemobrama webbii* Valenciennes).
Dinemus Poey, 1860, p. 161 (type species, *Dinemus venustus* Poey).

Body moderately elongate; compressed; lateral line complete; teeth in villiform bands on both jaws and on vomer and palatines; dorsal and anal fins comparatively long with several spines graduated in size and many rays; pelvics i,6; caudal i,8+8,i; paired chin barbels nearly as long as head; 4 branchiostegals; large ctenoid scales with several rows of ctenii and about 4 to 6 radiating folds in basal region but not reaching focus.

The species of *Polymixia* are distinguished by the following key:

1a. Dorsal fin rays IV or V, 34 to 37, usually 36; total number of gill rakers 11 to 13, usually 11 or 12. Eastern Atlantic, Cuba . . . . **P. nobilis** Lowe
1b. Dorsal fin rays V or VI, 26 to 32, usually 29; total number of gill rakers 14 to 21, usually 17 to 20. Western Atlantic . . . . . . **P. lowei** Günther
1c. Dorsal fin rays V or VI, 29 to 35, usually 30; total number of gill rakers 12 to 14, usually 13. Western Pacific . . . . . . **P. japonica** Günther

It is not possible to distinguish the extreme variants of *japonica* using the meristic characters of this key. The discussions in the descriptions of each species give an interpretation of the possible speciation and population divergence in the family.

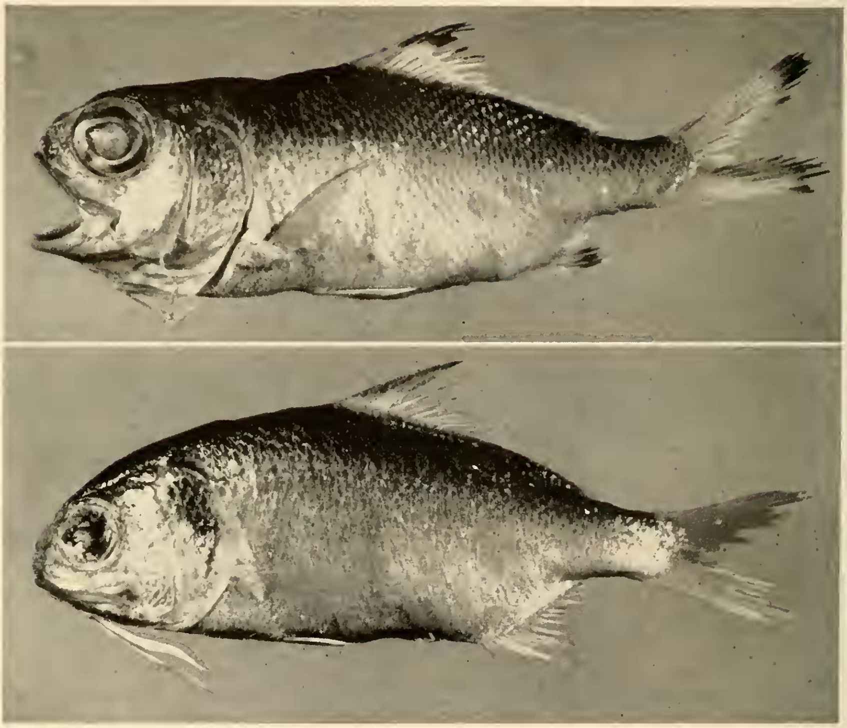
Polymixia nobilis Lowe

Polymixia nobilis Lowe, 1836, p. 198, pl. 4 (type locality, Madeira).—Günther, 1859, p. 17.—Goode and Bean, 1895, p. 243, fig. 241 (in part).—Fowler, 1936, p. 538, fig. 254.
Nemobrama webbii Valenciennes, 1843, p. 41, pl. 8 (type locality, Canary Islands).
Dinemus venustus Poey, 1860, p. 161 (type locality, Cuba) (in part).

Fourteen specimens ranging in standard length from 102 to 380 mm. were examined from the following localities: Madeira (8 specimens), USNM 23324, CNHM 47977 and 47978, BM 1855.11.29.10 (holotype), 1862.4.22.17, 1862.4.22.18, and 1895.5.28.1, MCZ 31510; St. Helena (1 specimen), BM 1867.10.83; Cuba (5 specimens), MCZ 21812 (paratype of *Dinemus venustus* Poey, 191 mm. standard length), and 4 specimens, MCZ 39168, from *Atlantis* Station 3439.

Description: The characters distinguishing this species are the greater number of soft dorsal fin rays, 36.1: 34–37, and the lower number of gill rakers, 11.7: 11–13. The dorsal spines range from IV to V. Other characters of lesser importance but showing interspecific differences are: Soft anal rays 16.6: 16–18; pectoral rays 16.7: 16–18; lateral line pores 33: 32–34; gill rakers short, longest raker 34 to 42 percent of diameter of orbit (table 7). A comparison of additional characters with *lowei* and *japonica* is given in tables 4 and 6.

In several specimens the dorsal fin was tipped with a prominent black blotch; anal and caudal fins usually somewhat dusky; body pale or dusky over a light silvery-gold; scales above lateral line area with posterior portion blackish. The possibility of sexual dimorphism in coloration could not be studied due to the few specimens and their poor condition.



Sexual dimorphism in coloration in specimens of *Polymixia lowei* from Cuba, collected by William C. Schroeder on *Atlantis* Expedition. Top, male, 137 mm. in standard length, from Station 3439; bottom, female, 143 mm., from Station 2981c.

GEOGRAPHIC DISTRIBUTION: Madeira Islands, Canary Islands, St. Helena, Cuba.

DISCUSSION: This species is apparently considerably rarer in the West Indian waters than *lowei*. Of 154 specimens of both species captured and preserved from Cuban waters by the *Atlantis* Expedition, only four, or 2.6 percent, proved to be *nobilis*. These four specimens were taken in water 295 fathoms in depth. Two of the specimens were taken in a haul with *lowei*.

Although Poey (1860) probably was not aware of the description of *lowei* (Günther, 1859) when he described *venustus*, he failed to recognize specific differences, since part of his type material (MCZ 21812, 2 specimens) represents specimens of *nobilis* and *lowei*.

Günther (1859) distinguished *lowei* from *nobilis* on the basis of six less rays in the dorsal fin, but when he had what he presumed to be intermediate material from the Pacific and Indian Oceans he later (1887, p. 34) lumped all into a single species, Goode and Bean (1895) and others followed this procedure.[1]

Smith (1949) referred to his Natal specimens as *nobilis*. His figure 283 shows 29 soft dorsal rays, which is out of the range for this species. Dorsal fin rays ranging from V, 27 to V, 38 were listed, but this range was probably summarized from the literature. No specimens from the Indian Ocean were available for my study. It appears that specimens from this area may represent *japonica*.

The higher anal fin ray count in specimens from Madeira compared to those from Cuba may show a real divergence in these populations when larger collections become available.

Polymixia lowei Günther

PLATE 1

Polymixia lowei Günther, 1859, p. 17 (type locality, Cuba); 1887, p. 34 (in part.—Rivero, 1936, p. 57.

Dinemus venustus Poey, 1860, p. 161 (type locality, Cuba) (in part).

Polymixia nobilis Goode and Bean, 1895, p. 243 (in part).

Polymixia nobilis virginica Nichols and Firth, 1936, p. 2 (type locality, Cape Henry, Va.).

A total of 235 specimens ranging in standard length from 60 to 198 mm. were examined from the following localities: Cuba (152 specimens), BM 1852.9.13.216 (holotype), MCZ 21812 (paratype of *Dinemus venustus* Poey, 134 mm. standard length), and 150 MCZ

[1] While this paper was in press Maul published an account (Bol. Mus. Municipal do Funchal, Madeira, No. 7, art. 17, pp. 9–11, 1954) in which he recognized two species on the basis of a higher dorsal count in *nobilis*, 40 to 42 (spines plus rays), compared to 35 in *lowei*, and that the body of *nobilis* was "rather deep." The range of variation of the dorsal rays is considerably greater than Maul indicates and the amount of separation much closer. I find the depth of the body to vary considerably in respect to size and to some extent sex, the females being somewhat deeper. I did not find any notable differentiation in body depth when comparing specimens of equal size of these species. However, *nobilis* appears to attain a much larger size and, consequently, greater depth.

TABLE 1.—*The number of dorsal fin rays in species of* Polymixia, *segregated by locality*

Species	Locality	Dorsal fin rays														
		IV	V	VI	26	27	28	29	30	31	32	33	34	35	36	37
nobilis	Madeira	2	6	–	–	–	–	–	–	–	–	–	–	1	5	2
	St. Helena	–	1	–	–	–	–	–	–	–	–	–	–	–	1	–
	Cuba	1	4	–	–	–	–	–	–	–	–	–	1	1	2	1
lowei	Cuba	–	146	6	1	7	30	77	30	4	3	–	–	–	–	–
	Jamaica	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–
	Virgin Islands	–	7	–	–	–	1	2	4	–	–	–	–	–	–	–
	Gulf of Mexico	–	54	1	–	12	36	7	–	–	–	–	–	–	–	–
	U. S. Atlantic Coast	–	16	1	–	4	10	3	–	–	–	–	–	–	–	–
japonica	Japan	–	13	1	–	–	–	–	3	1	3	3	3	1	–	–
	Philippines	–	12	–	–	–	–	3	7	3	–	–	–	–	–	–
	Hawaii	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–

TABLE 2.—*The number of gill rakers in species of* Polymixia, *segregated by localities. The raker at the angle of the arch is included in the count of the lower limb as well as the total number*

Species	Locality	Number of gill rakers																							
		Upper limb						Lower limb							Total										
		3	4	5	6	7	8	8	9	10	11	12	13	14	11	12	13	14	15	16	17	18	19	20	21
nobilis	Madeira	4	4	–	–	–	–	3	5	–	–	–	–	–	1	5	2	–	–	–	–	–	–	–	–
	St. Helena	1	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
	Cuba	4	1	–	–	–	–	4	1	–	–	–	–	–	4	1	–	–	–	–	–	–	–	–	–
lowei	Cuba	–	1	10	32	98	1	–	–	5	5	39	78	15	–	–	–	1	4	3	4	26	14	74	16
	Jamaica	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–
	Virgin Islands	–	–	1	6	–	–	–	–	1	1	5	–	–	–	–	–	–	1	–	1	5	–	–	–
	Gulf of Mexico	–	–	–	41	17	–	–	–	1	26	30	1	–	–	–	–	–	–	1	25	16	15	1	–
	U. S. Atlantic Coast	–	–	–	9	8	–	–	–	–	8	8	1	–	–	–	–	–	–	–	7	3	6	1	–
japonica	Japan	–	13	–	–	–	–	–	10	3	–	–	–	–	–	–	10	3	–	–	–	–	–	–	–
	Philippines	1	10	2	–	–	–	1	12	–	–	–	–	–	–	3	8	2	–	–	–	–	–	–	–
	Hawaii	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–

TABLE 3.—*Frequency distribution of a character index formed by subtracting for each individual specimen the total number of gill rakers from the number of soft dorsal fin rays*

Species	Locality	Character index																				
		5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
nobilis		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	6	6
lowei		1	–	9	32	71	33	43	13	9	3	5	2	–	–	–	–	–	–	–	–	–
japonica	Japan	–	–	–	–	–	–	–	–	–	–	–	–	3	1	2	2	3	1	–	–	–
	Philippines	–	–	–	–	–	–	–	–	–	–	1	–	11	1	–	–	–	–	–	–	–
	Hawaii	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–

TABLE 4.—*The number of vertical scale rows in species of* Polymixia

Species	Locality	Vertical scale rows																
		48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
nobilis		–	–	–	–	–	–	–	2	1	–	–	–	–	–	–	–	–
lowei		–	–	–	1	1	2	3	1	4	6	5	3	2	–	1	–	–
japonica	Japan	–	–	–	–	–	1	–	1	1	–	–	2	2	2	–	–	1
	Philippines	1	–	–	–	2	2	–	1	2	2	2	–	–	–	–	–	–
	Hawaii	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–

TABLE 5.—*The number of anal and pectoral fin rays and pores along the lateral line in species of* Polymixia, *segregated by locality*

Species	Locality	Anal rays								Pectoral rays				Lateral line pores							
		III	IV	13	14	15	16	17	18	15	16	17	18	29	30	31	32	33	34	35	36
nobilis	Madeira	–	4	–	–	–	–	3	1	–	1	2	1	–	–	–	–	–	2	–	–
	Cuba	1	4	–	–	–	5	–	–	–	4	–	1	–	–	–	2	3	–	–	–
lowei	Cuba	3	90	–	5	74	10	1	–	13	28	3	–	–	–	–	1	5	9	2	–
	Jamaica	–	1	–	–	–	1	–	–	–	–	1	–	–	–	–	–	–	1	–	–
	Virgin Islands	–	7	–	–	4	3	–	–	–	7	–	–	–	–	–	1	4	–	–	–
	Gulf of Mexico	–	56	1	5	48	2	–	–	5	48	1	–	–	–	2	9	16	12	5	1
	U. S. Atlantic Coast	–	16	–	2	14	–	–	–	5	8	–	–	–	–	1	1	9	6	–	–
japonica	Japan	–	13	–	1	3	9	–	–	1	10	2	–	–	–	1	1	3	5	–	–
	Philippines	–	12	–	3	9	–	–	–	3	10	–	–	1	1	6	4	1	–	–	–
	Hawaii	–	1	–	–	–	–	1	–	–	1	–	–	–	–	–	–	1	–	–	–

TABLE 6.—*Characters of populations of* Polymixia *expressed as a percentage of the standard length*

Species	Locality	Head length								Barbel length																
		31	32	33	34	35	36	37	38	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
nobilis		–	–	3	–	2	2	2	–	–	–	1	–	–	1	1	2	–	–	1	–	–	–	–	–	–
lowei		–	5	12	11	8	3	–	–	1	3	2	3	7	12	4	2	1	1	–	–	–	–	–	–	–
japonica	Japan	1	–	3	4	2	1	1	–	–	–	–	–	3	1	1	2	2	–	–	–	–	–	–	–	–
	Philippines	–	–	1	2	5	3	1	1	–	–	–	–	1	–	–	3	1	2	–	1	1	1	–	1	1
	Hawaii	–	–	–	–	–	1	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–

Species	Locality	Orbit diameter					Pectoral fin length							Upper jaw length					
		9	10	11	12	13	18	19	20	21	22	23	24	16	17	18	19	20	21
nobilis		2	3	1	2	1	1	1	–	1	–	–	–	–	2	1	–	–	–
lowei		–	9	27	3	–	–	–	4	2	5	13	1	–	2	7	9	8	–
japonica	Japan	–	3	–	8	–	–	2	3	3	1	–	–	1	2	–	2	3	1
	Philippines	–	3	3	5	2	–	–	2	3	5	3	–	–	4	7	1	1	–
	Hawaii	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	1	–

specimens taken on Harvard-Havana *Atlantis* Expedition from Stations 2950, 2961D, 2962, 2963C, 2980B, 2981C, 2982, 2982A, 2983, 2987, 2987A, 3324, 3328, 3386, 3389, 3393–94, 3401, 3416, 3421–23, 3427–28, 3430–32, 3435–39, 3478; Jamaica (1 specimen), MCZ 33858; Virgin Islands (7 specimens), USNM 102151–157, Johnson-Smithsonian Expedition; Gulf of Mexico (58 specimens), USNM 157752 and 157753 (8 specimens off Pensacola, Fla.), USNM 117089, from stomach of *Paralichthys oblongus* at 168 fathoms, 117090, 117091, and 157751 (19 specimens from near Tortugas, Fla.), USNM 157749 and 157754 (25 specimens off Mississippi), USNM 157750

TABLE 7.—*The longest gill raker of the first right arch expressed as a percentage of the diameter of the orbit in* Polymixia nobilis *and* P. lowei. (*Numbers in parentheses refer to* P. nobilis.)

Standard length (mm.)	Percent												
	34–35	36–37	38–39	40–41	42–43	44–45	46–47	48–49	50–51	52–53	54–55	56–57	58–59
60–99	–	–	–	–	–	–	1	1	2	2	–	1	1
100–139	–	–	(1)	–	–	4	3	5	4	3	–	–	–
140–179	–	(1)	1 (1)	1	3	1	2	3	1	1	1	–	–
180–219	(1)	–	–	–	1 (1)	–	–	–	–	–	–	–	–

(2 specimens off Corpus Christi, Tex.), CNHM 46388 (4 specimens from various areas of Gulf of Mexico); Atlantic Coast (17 specimens), AMNH 13569 (2 specimens, south-southeast of Cape Henry, Va., cotypes of *Polymixia nobilis virginica* Nichols and Firth), MCZ 37702 (14 specimens, 40°03′N., 70°25′W.), and MCZ 37411 (1 specimen, 40°02′N., 70°24′W.).

DESCRIPTION: This species is distinguished by the low number of soft dorsal fin rays, 28.7: 26–32, and the high gill raker count, 18.8: 14–21. The dorsal spines range from V to VI. Other characters showing some interspecific differences are: Soft anal rays 15: 13–17; pectoral rays 15.8: 15–17; lateral line pores 33.4: 31–36; gill rakers long, longest raker 39 to 58 percent of diameter of orbit. A comparison of the length of head, barbel, pectoral fin, upper jaw, diameter of orbit, and vertical scale rows with the other species is given in tables 4 and 6.

Sexual dimorphism in coloration is markedly evident, the most pronounced being the intense black on the outer portion of the longest rays of the anal fin and lobes of the caudal fin in the males, pale or slightly dusky in the females. Coloration of the males usually larger than 120 mm. standard length: outer one-third to one-half of the dorsal fin between 4th and 5th spine and the first 6 rays prominent black, some whitish below this spot or blotch, remainder of fin pale;

outer third of first 7 or 8 rays of anal fin heavy black, remainder pale; tips of outer rays of caudal fin black; pectoral fin pale to transparent; 1st and 2d ray of pelvic fin slightly milky, remainder pale or clear; snout and interorbital portion of head with enlarged or swollen, pale or milky jellylike tissue; barbel pale, some dusky near base; jaws dusky; iris silvery to light golden; body above lateral line darker, particularly predorsal area, due to heavier blackish pigmentation on posterior portion of scale just before ctenii; body below lateral line pale, silvery or light blue iridescence; a stripe of silvery along lower part of caudal peduncle, on each side, joining anteriorly on belly between bases of pelvic fins. Coloration of gravid females ranging in standard length from 127 mm. or larger: dorsal fin with some dusky or blackish at outer portion of longest rays; anal fin pale, in some slightly milky; caudal fin sometimes dusky at tips of outer rays; pectoral and pelvic fins clear or pale; body generally lighter and more silvery. Juvenile specimens, 60 to 70 mm. in standard length, could not be sexed using a binocular microscope, but some had the dorsal, anal, and caudal rays tipped in dusky, more so than in the larger, gravid females. These specimens were probably males commencing to develop the definitive adult coloration.

Geographic distribution: West Indies, Gulf of Mexico, Atlantic shelf of United States north to Long Island, N. Y.

Discussion: Poey's (1860) account of *venustus* included one of the diagnostic characters, a dorsal fin ray count of V,28, but his illustration, plate 14, figure 1, is only an undescriptive line drawing. On the basis of his description and one cotype (MCZ 21812, 134 mm. standard length) I place *venustus* in the synonymy of *lowei*. The other cotype of *venustus* (also MCZ 21812) represents *nobilis*. Data for the two cotypes of *P. nobilis virginica* Nichols and Firth (AMNH 13569, 96 and 98 mm. standard length, dorsal fin rays V,28 and V,29; anal fin rays IV,15; pectoral rays 15; lateral line pores 34; gill rakers total 17 and 20) shows no real departure from specimens of *lowei* from other localities and it is, therefore, also placed in the synonymy of *lowei*. The meristic data of great interest in *lowei* and *nobilis*, since both occur together, is the negative correlation between the total number of gill rakers and the number of soft dorsal fin rays. *P. lowei* with a lower number of dorsal rays has a higher number of gill rakers (tables 1 and 2).

The frequency distributions of the total number of gill rakers in *lowei*, segregated by locality, shows the mode of specimens from Cuba to fall on 20 while it is 17 for those from the Gulf of Mexico. A minor population divergence should not be associated with this difference. It is due to the decrease in the number of gill rakers with increase in size. This regression is shown in crude form in table 8. Specimens from the Gulf of Mexico attained a larger average size and consequently had fewer rakers.

Throughout its range, *Polymixia* has been reported as quite rare. Rivero (1936) reported two specimens of *lowei* from Cuba and mentioned the rarity of the species. We now can report *lowei* as being relatively common. Although 150 specimens were captured and saved by the Harvard-Havana *Atlantis* Expedition, many specimens were discarded for lack of adequate storage facilities. William Schroeder, Woods Hole Oceanographic Institution ichthyologist attending this expedition, informed me that one trawl haul yielded more than 300 specimens. This haul could have contained *nobilis* as well as *lowei*, but most of the specimens probably represented the latter species.

TABLE 8.—*A crude regression analysis showing decrease in the number of gill rakers with increase in size in* Polymixia lowei.

Standard length in mm.	Total number of gill rakers							
	14	15	16	17	18	19	20	21
60–99	–	–	–	9	16	18	46	5
100–139	–	1	3	3	15	1	30	8
140–179	–	4	1	9	11	3	3	–
180–219	1	1	–	–	–	–	–	–

There is considerable variability in the depth of water in which *Polymixia* is taken. This data is summarized for *lowei* in western Atlantic waters in table 9, several localities segregated. In Cuban waters *lowei* was almost consistently taken at 200 to 300 fathoms. The specific localities of the stations listed for the Cuban specimens are given by Chace (1940).

TABLE 9.—*Depth of water, in fathoms, in which* Polymixia lowei *was taken.*

Locality	0–49	50–99	100–149	150–199	200–249	250–299	300–349
Cuba	–	–	–	10	115	23	1
Gulf of Mexico	15	–	1	8	26	1	–
U. S. Atlantic Coast	–	2	15	–	–	–	–

Polymixia japonica Günther

Polymixia japonica Günther, 1877, p. 436 (type locality, off Inoshima, Japan).—Steindachner and Döderlein, 1883, p. 221, pl. 4, fig. 2.—Jordan and Fowler, 1902, p. 18.—Tanaka, 1913, p. 218, pl. 59, fig. 221.—Jordan and Hubbs, 1925, p. 209.

Polymixia nobilis Günther, 1887, p. 34.—Kamohara, 1952, p. 29, fig. 22.

Polymixia berndti Gilbert, 1905, p. 616, pl. 78 (type locality, Honolulu, T. H.)

A total of 28 specimens ranging in standard length from 94 to 171 mm. were examined from the following localities: Japan (14 specimens), UMMZ 142823 and 164783 (2 specimens), USNM 38829, 57595, 71273, 148777, 148778, 151797 (totaling 7 specimens), CNHM 55422 (3 specimens), AMNH 1963 (1 specimen), BM 1880.5.1.3 (holotype, *Polymixia japonica* Günther, Inoshima, Japan; *Challenger* Expedition); Philippine Islands (14 specimens), USNM 98857–98861 (13 specimens, collected by *Albatross* Expedition at Capitancillo Island and Tagola Point Light; Hawaii, USNM 51607 (holotype, *Polymixia berndti* Gilbert, Honolulu).

Description: Soft dorsal fin rays 31.2: 29–35; dorsal spines V or VI; total number of gill rakers 13.1: 12–14; soft anal rays 15.3: 14–17; pectoral rays 15.9: 15–17; lateral line pores 32.2: 29–34. A comparison of the length of head, barbel, pectoral fin, upper jaw, diameter of orbit, and vertical scale rows among two Pacific populations is given in tables 4 and 6.

Specimens from Japan and Hawaii with a large black spot or blotch on outer third of longest rays of dorsal fin in the area of the first six rays. This conspicuous black spot dusky in Philippine specimens, not nearly as evident as in specimens from Japan. This difference may be due to the poor condition and preservation of the Philippine specimens and not a population divergence, for all specimens had frayed fins. Anal and caudal fins pale or with some dusky, particularly on the margin of the caudal; pectoral fin pale; pelvic pale with some whitish on edge of outer rays. Coloration of head and body as in Atlantic forms.

Günther (1887) reported on specimens from Japan, but his illustration, plate 1, figure B, probably represents *nobilis* because the dorsal fin has 36 soft rays. Steindachner and Döderlein (1883), no doubt, inadvertently omitted the barbels from their plate 4, figure 2.

Geographic distribution: Japan, Philippines, and Hawaiian Islands. *Polymixia* has been reported from the Andaman Sea (Alcock, 1889, p. 381 and 1891, p. 23) and Natal, East Africa (Barnard, 1925, p. 359; Smith, 1949, p. 149), but I am unable to determine what form is represented in these areas since the reported descriptions are incomplete and no specimens were available for my examination.

Discussion: The differentiation of *Polymixia* in the Pacific area is not as clear cut compared with the Atlantic forms, but I allocate the rank of species to *japonica* owing to the nature and measure of strong divergence among the three forms.

P. japonica has differentiated considerably, although incompletely, in certain meristic characters, but in varying proportions from *lowei* and *nobilis*. It occupies an intermediate position in a comparison of frequency distributions of the most critical meristic characters, the number of dorsal fin rays and the total number of gill rakers (tables

1 and 2). On the basis of my limited material, counts of the number of soft dorsal fin rays reveal that 83 percent of all specimens of *nobilis* and *japonica* are "identifiable" (portions of the frequency distributions of each species showing no overlap), whereas only 43 percent of the specimens of *lowei* and *japonica* are similarly identifiable. Using the total number of gill rakers as a criterion to distinguish these species, only 25 percent of all specimens of *nobilis* and *japonica* can be segregated, and 97 percent of *lowei* and *japonica*. A slightly higher percentage of specimens are distinguishable by using a character index (table 3) formed by subtracting the total number of gill rakers for each individual specimen from the number of soft dorsal fin rays. With this method 85 percent of all specimens of *nobilis* and *japonica* are separable and 97 percent of *lowei* and *japonica* are separable. If we consider differentiation among these forms on the basis of these percentages only, *nobilis* and *japonica* might be considered subspecifically distinct, and *lowei* and *japonica* as having reached a specific level of differentiation. Thus, these data suggest that *nobilis* and *japonica* are more closely related than are *lowei* and *japonica*. This may be an erroneous assumption, for the close relationship of *japonica* with each of these species involves different sets of characters. Also, if two extreme variant specimens (table 3) were removed (one representing a specimen of *nobilis* and one a specimen of *japonica*) the three forms would be completely separable.

P. japonica occasionally has a sixth dorsal spine, the total number ranging from V to VI as in *lowei*, but *nobilis* occasionally has one less spine, the total number ranging from IV to V.

This measure of strong divergence in *japonica* leads one to conclude that the principal problem yet to be solved is the determination of the exact nature of divergence among the Pacific and Indian oceanic populations. This opinion is supported by the following factors: (1) *lowei* and *nobilis* definitely react as species where they have been found together in Cuban waters, (2) *japonica* is geographically isolated from the Atlantic forms, and (3) populations of *japonica* show partial differentiation in some erratic frequency distributions of meristic characters, being not nearly as stable as Atlantic populations. However, this determination must await additional exploration and study.

The Philippine specimens of *japonica* show some differentiation on a racial level from the Japanese specimens in the number of dorsal fin rays, lateral line pores, and vertical scale rows and in the length of the barbel. These differences require much verification before any conclusions can be formed regarding their real significance.

I find that the primary characters listed by Gilbert (1905, p. 616) distinguishing *berndti* from *japonica* (longer maxillary, larger scales, bluntly rounded snout and more slender body) cannot even be considered as minor variations because all of them are similarly represented in the range of variation of characters for specimens I have examined from Japan and the Philippine Islands. Some of the more important ones are compared in tables 4 and 6.

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